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GUIDELINES FOR THE DEVELOPMENT OF APPROPRIATE BUILDING MATERIALS PRODUCTION FOR LOW-COST HOUSING CONSTRUCTION

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I. INTRODUCTION

1. The housing problem in developing African countries has worsened during last decade in the face of increased economic problems, high population growth rates, high rural-urban migration and low per capita incomes. The annual addition to the housing stock has not kept pace with the demand. Low income earners who constitute the majority of the population have been affected the most and many live in deplorable shelter conditions or have no shelter at all. The seemingly unending rural-urban drift has encouraged the development, in urban areas, of squatter settlements where non-durable temporary houses provide much needed shelter.

2. The continuing interest in the development of building materials derives from the fact that they constitute the single largest input in housing construction, accounting for as much as 70% of a low cost house. At the same time the building materials sector remains a bottleneck in low-cost housing to serve the needs of the poor because of high priced products turned out by essentially capital intensive plants. On the other hand, opportunities for improving traditional systems for producing building materials based on locally available resources have not been adequately exploited and in many countries efforts that were initiated to promote the development of local building materials could not be sustained. The results of research and development activities on appropriate building materials technologies and building techniques have not been extensively adopted and promoted in practical field projects. Part of the reason for this situation is the prevailing social and psychological bias against the use of materials which are considered to be fit only for the poor, and the failure to plan and implement specific programmes aimed at systematically developing the increased production of local materials that would enhance the construction of lower cost houses to meet the needs of the poor in both urban and rural areas. Such programmes should be formulated taking due cognizance of the role of individual and community-based self-help efforts in materials production, as well as that of private small scale enterprises that can be set up in decentralized locations to meet the requirements of small scattered markets.

3. The purpose of this document is to provide guidelines that should assist African governments in formulating and implementing measures that would contribute to a greater development of appropriate building materials production systems in support of low-cost housing construction. It is intended to be used by government decision-makers, officials and agencies with responsibility for the development and promotion of local building materials production and low-cost housing schemes. Non-governmental organizations and community groups with interest in low-cost housing schemes should also find the guidelines useful.

4. Chapter II of the document considers some elements of the planning for the development of low cost building materials production capacities. It outlines a basic approach which should be adopted to achieve increased supply of building materials and then discusses the choice of scale of production and the choice of appropriate production technologies. The chapter ends with an overview of some technologies for the production of selected building materials in small scale. Chapter III covers the development and consolidation of production technology in the local environment and emphasizes the conditions

for setting up pilot plants for this purpose. In chapter IV guidelines are given on aspects of the popularization of appropriate production technologies including schemes for technology transfer, demonstration of the use of building materials and publicity campaigns. The development of small-scale enterprises for building materials production is covered in chapter V and finally chapter VI focuses on the institutional support required for the enhancement of the production of low-cost building materials.

II. PLANNING FOR THE DEVELOPMENT OF LOW COST MATERIALS PRODUCTION CAPACITIES.

Basic approach

5. In addressing the issue of developing the production of lower cost building materials in African countries, it is important to review the deficiencies of existing production strategies and to formulate a new approach which would overcome those deficiencies and pave the way for a breakthrough in the search for solutions to the low cost building materials problem.

6. Various studies undertaken by the United Nations Economic Commission for Africa, ECA, have revealed that an approach based on the "development and popularization of appropriate and proven production technologies" would constitute a rational approach, in the context of the African experience, for increasing the supply of lower priced building materials. This approach has four basic elements or stages which are not completely mutually exclusive, but are separated for the sake of simplicity:

(i) Development of pilot-scale production of selected building materials: this may involve the consolidation of laboratory-stage research or the improvement of an existing traditional technology.

(ii) Transfer of newly-developed or improved technology: this involves essentially training technicians and entrepreneurs in production, processing and quality control.

(iii) Setting up of demonstration buildings and training in the use of the new or improved building materials.

(iv) Popularizing the production and use of the building materials. This will include publicity campaigns and assistance to entrepreneurs to set up new production units based on the "new" technologies.

7. Guidelines for achieving maximum impact at each of the stages described above are discussed in more detail in chapters III to V. The rest of this chapter considers other issues which are considered important in the formulation of plans for developing low-cost building materials production.

Assessment of raw materials availability

8. The types of raw materials available in a country provide a basis for determining the range of building materials that could be developed for low-income housing. There is ample documentation indicating the availability, in varying quantities, of soils, limestone, dolomite, clay, pozzolana, agricultural and mining/industrial wastes etc., which would support the production of cheap building materials in the countries of the region. The problem, however, is that in general, comprehensive information on the existing deposits regarding their location, size and suitability is lacking. Several small deposits which could support decentralized small-scale production activities have not yet been mapped.

9. The assessment of raw materials resources should therefore be seen as one of the important activities in the planning efforts towards the further development of the production of building materials to support housing for the poor. The following actions are necessary:

(i) Assemble existing information on raw materials available at various offices, department of mines, geological survey department, research institutes and materials testing laboratories, etc., and also from the reports of special geological studies undertaken under consultancy and technical assistance contracts. At the local level, preliminary information on raw materials can be obtained from an examination of materials used in traditional construction, as well information from local residents about sites where some building materials were produced in the past;

(ii) Analyse above information to determine its scope in terms of type of raw materials, geographical distribution, quantities, quality, current use, and accessibility,

(iii) Document and store information in a readily retrieval and useable form.

10. The above assessment of existing information will help in determining the extent and scope of additional studies which would have to be undertaken, both in the short-term and long-term, to support production activities. The facilities and capabilities of building research institutes and testing laboratories will need to be developed to support programmes for the evaluation of raw materials.

11. An important aspect of the availability of raw materials is their accessibility to permit exploitation by entrepreneurs and other interested groups. Accessibility must be considered from two perspectives: the physical access in terms of a road link and the ease of exploitation with respect to land ownership rights and payment of royalities. Problems of raw materials accessibility do exist in African countries and measures need to be devised to remove bottlenecks which would otherwise frustrate efforts at wide-scale promotion of building materials production.

Scale of production

12. Large-scale capital intensive plants have, in general, failed to make an appreciable impact on the building materials market in African countries due mainly to the high import content of production inputs including maintenance. This is evidenced by:

(i) Lack of qualified local technical and managerial personnel;

(ii) Maintenance and repair problems caused by (i) and the lack of foreign exchange to import needed spare parts,

(iii) As a result of (i) and (ii), there is low utilization of installed capacities which results in high production costs.

13. The net result of the above factors is the high cost of factory produced building materials, which, in areas located far away from the centre of production is increased further by high transportation costs. The problems associated with the large-scale capital-intensive plants in contemporary Africa emphasize the case to focus renewed attention on small-scale building materials enterprises, particularly in the context of producing materials for low-cost housing construction.

14. Building materials production in small-scale has the following relative advantages:

(i) Cost per workplace is low. It has been established that capital assets per worker in traditional and small-scale units are lower by a factor of at least 10 over modern medium and large-scale building materials production units,

(ii) Low foreign exchange component. For example, a small-scale intermediate technology plant in the burnt brick industry has capital intensity less by a factor of about 6.7 than a large-scale plant and import content is about 15% compared to 75% of production costs;

(iii) High employment potential. For example, small-scale brick plants require about 20 times more labour than a highly automated plant of the same output;

(iv) Technical simplicity of production systems provides advantages in ease of operation, repair, maintenance and management, and potential for local manufacture;

(v) Low investment costs and simplicity of production systems makes small-scale production enterprises accessible to small enterpreneurs with little financial resources ;

(vi) Small-scale production units mean that production can be decentralized. This in turn has several advantages: small-scale plants can make use of low-quality and residual raw materials in areas where the

demand is low, decentralized production can provide materials where and when supplies from more centralized plants are not available; prices of locally manufactured materials may be cheaper than centrally produced and/or imported materials as transport costs from decentralized production centres to local markets may be lower than from centralized production systems.

15. In sum, the conditions which favour small-scale over large-scale production, are all prevalent in Africa: low wage regimes, shortage of foreign exchange; poorly developed industrial base; insufficient infrastructure and technical skills; small and widespread markets. There is therefore a strong case for making this level of production the major thrust of building materials strategies by African governments.

Choice of production technology

16. It was concluded in the foregoing section that small-scale production technologies are the most appropriate for the situation in African countries for the realization of affordable building materials for low cost housing. In the small-scale sub-sector however, different technologies can be found for the various types of materials that could be developed and promoted. An important task that needs to be undertaken therefore is to examine the technologies available for a given material and to decide on those which could be adopted in the country to meet the requirements of different types and levels of demand and end uses in the low-cost housing sector.

17. Available technologies can be classified broadly into two groups - traditional and intermediate. The traditional technologies which in most cases have been used for centuries, are usually relatively unsophisticated, and tend to have the following characteristics: relatively high labour and low capital intensities; inefficient use of raw materials, low product quality, and irregular (seasonal) supply. The products however satisfy the criterion of affordability and have thus served the needs of the majority of the rural and peri-urban population for housing.

18. The current concern of African governments is however to provide housing which is not only affordable but is also reasonably durable. And this is an area where many materials from traditional production units are deficient. What is required then is to introduce improvements in the processing and quality control procedures to achieve a higher productivity and better quality products. And this can often be done with only small capital outlays in equipment and tools. For example, in brickmaking, the introduction of a simple pugmill can lead to improved mixing of the clay with beneficial effects on the quality of the finished product. Intermediate technologies which represent an improvement over traditional methods, usually with some amount of mechanization, provide alternative technologies for application in the small-scale building materials sector.

19. In order for improved or intermediate technologies to have an impact on building materials production, they should be amenable to replication. This can take place effectively if the technology package can be obtained locally with little or no foreign input. Experience in Kenya, for example, showed that the adoption of the "Brepak" soil compaction machine eventually had a negative effect on stabilized soil technology transfer because the machine was available only from the United Kingdon. Intermediate technologies, particularly those "imported" from other countries should be proven in the local environment before they are adopted for widespread application. This is necessary since cases of failure in the early stages of technology promotion can jeopardize its wider adoption.

20. The choice of technology for a given building material would depend on the level of production envisaged, and whether it is for a commercial venture or for self-help community projects. The following factors should be considered in decisions on appropriate production technologies:

(i) What technologies, traditional or intermediate, are available already in the country and what are their relative merits from the point of view of production of reasonably cheap building materials?

(ii) If the technology is new, for example as in the case of rice husk ash cement, has sufficient research and development work been carried out locally to determine its viability?

(iii) Has the technology been developed to the extent that a complete technical and business package is available particularly for use by entrepreneurs? If not, are there local institutions which could undertake the necessary development towards this end?

(iv) If the technology requires the use of equipment and tools, can these be fabricated locally, and if so can the fabrication capacity sustain increased demands resulting from successful popularization schemes; or will there be need to take simultaneous measures to strengthen existing capacities?

(v) Will the adoption of the technology entail continuing dependence on imported equipment and spares as well as some raw material inputs?

(vi) Can the technology, for example, if it is intermediate, be easily mastered by local technicians and operatives?

(vii) What will be the attitudes of local labour towards labour-intensive aspects of the production process? For example, will manual mixing of clay by trampling be acceptable?

(viii) Are there adequately developed technical back-up services to support the propagation of the technology?

(ix) Will the technology really lead to the production of reasonably low-cost materials to meet the objective of low-cost housing?

A brief overview of some of the available technologies that are amenable to small-scale production of selected local building materials is given below.

Technologies for the production of low-cost building materials

Stabilized soil

21. Ordinary soil is the most popular material for wall construction, especially in the rural areas of Africa. Soil in its natural state however has an intrinsic problem which emanates from its low resistance to weakening and erosion by water. Strength and durability properties of soil can be improved by stabilization and the application of a compactive effort using a press. The most commonly used stabilizing agents are cement, lime and bitumen depending on what is available locally. Many different types of block press have been developed and used in various parts of the world, and several models can be found in African countries. Local adaptation of presses developed outside the African region has also be undertaken, for example CENEEMA (Cameroun), TEK-BLOCK (Ghana), WECO/CINVA RAM (Kenya). Soil block presses fall into three main categories:

(a) Manual presses of which the Cinva-ram, and its derivates found in many African countries (see fig. 1), is the most widely produced and used. Output ranges from 200 to 500 blocks a day. The presses are priced between US$ 200 and US$ 400. The block press developed by the Nigerian Building and Road Research Institute (NBRRI) produces three blocks per operation. It has an estimated daily output of 700-800 blocks and sells for about US$ 1000.

(b) Hydraulic manual presses, which produce high rates of compaction, about 2 to 5 times that given by manual presses. An example is the Brepak press (see fig. 2), developed in the United Kingdom and field tested in some African countries. It has an estimated daily output of 300 blocks and costs approximately US$ 2000.

(c) Powered presses with varying degrees of automation, outputs over 2000 blocks per day, and with prices starting at around US$ 3000.

22. An important criterion in the choice of block press is its amenability to local fabrication and in this respect, the manual presses have a clear advantage. Improvement of their compactive effort should be the focus of further research and development work.

23. Using locally manufactured equipment of the Cinva-ram type, typical start-up cost for a small scale operation is estimated at around US$ 5000. This includes the block press, sieving screen, small clay crusher, ancillary tools, working shed and working capital.

24. Manual block presses have been used extensively on co-operative and community housing schemes in Africa. There is considerable potential for on-site manufacture of blocks in the context of NGO and government schemes where production and quality control can be closely supervised. Commercial scale production is still in the early stages of development. An important consideration should be the siting of production units near potential demand points to minimize transportation costs and breakages in transit.

Burnt bricks and tiles

25. Burnt bricks have been produced by small scale artisanal methods in several African countries over many years. The production process is entirely labour-intensive and requires very little capital. Clay winning, transportation, mixing and moulding are all carried out manually. The bricks are sun-dried and fired in field clamps using firewood and agricultural wastes. Bricks produced by such plants however, tend to be of variable quality arising mostly from the poor selection of raw materials, inconsistent production methods and inefficient burning methods. Basic improvements at little additional cost are needed to enhance product quality. Training in basic quality control procedures and the introduction of simple field testing methods would be beneficial.

26. Efforts at improving hand-moulded bricks include the development of the table mould which has been pioneered by organizations like the Intermediate Technology Workshop of the United Kingdom and the Central Building Research Institute of India (see fig. 3-5). Stiff bricks of excellent shape and clean edges can be produced by this device which could be fabricated locally in many African countries form box section steel, steel angle and timber, or timber only. The output of the table mould is about 600-800 bricks per day. Manual brick presses (200 to 300 bricks per hour), power driven and semi-automatic presses that produce up to about 2000 bricks per hour are also available, but the latter are not suitable for small scale operations.

27. Crushing is required when the clay is hard and dry. Powered crushing rollers can be used but are expensive and require a source of power. They may not be economic at scales of production of less than 5000 bricks per day. Manually operated crushers, which could be fabricated locally in Africa, are available at prices ranging from US$ 1800.00 to US$ 3800.00. The pendulum crusher developed by Intermediate Technology Workshops (U.K.) comes in two models which are operated, respectively, by one person and four persons (see fig. 6).

28. Traditional and small-scale plants use air drying for the green bricks. Protection from sunlight and rainfall is desirable. Use of drying racks allows large quantities of green bricks to be dried under a relatively small area of cover which is necessary during rainy seasons, for continuous operation.

29 For all year round operations, permanent intermittent kilns are preferred over field clamps. Although wasteful of energy, intermittent kilns appear to be the best option for small-scale operations from the point of view of cost and simplicity of operation. Wood is likely to continue to be the major fuel except in areas near to coal, or to high concentrations of agricultural residues with no important competitive use. The long-term ecological impact of fuel wood use should be kept in view. Mixing of granular fuel, such as coal or rice husk with the clay before moulding can reduce fuel consumption by up to 5%.

30. It is estimated that a typical small-scale brick plant (about 10,000 bricks a week capacity) employing improved techniques and equipment at all stages of the production process-table moulds, improved handling equipment, and permanent intermittent kiln would cost between US$ 25000 - 40000 for equipment, buildings and infrastructure, including working capital of US$ 3000 - 5000.

31. One disadvantage of the standard clay brick compared with concrete blocks is the high labour cost for laying because of lack of suitably qualified bricklayers. While training to increase labour productivity is urgently needed in many countries, attempts have also been made to introduce larger sized bricks in small scale production. In Nigeria, the introduction of a brick of size 290 x 140 x 100mm was found to have led to a marked improvement in the productivity of masons.

32. The production of clay roofing tiles at small scale level has not been well developed in Africa. Current production and use is low. The methods for clay winning, preparation and mixing are similar to those used for brickmaking. The suitability of clays for tile-making should however be carefully assessed: clays of higher plasticity and fine consistency are required. Mixing of clay should be throughly done to minimize porosity. Good quality tiles are usually pressed or extruded using high cost equipment. Extrusion is expensive and cannot be considered for small-scale production. A major current concern is for the development of low-cost manually operated tile presses which can be fabricated locally in African countries. A robust roof structure, which is expensive in timber, is required for clay tiles because of the relatively high weight per square metre (35-90 kg compared with 5 kg for corrugated iron sheets). The search for a low-cost roof structure should therefore be on the research agenda on clay tile technology.

Lime

33. Lime is an ancient building material and has been produced for many years in several African countries at the small-scale level. Product quality has however been a problem and the advent of ordinary portland cement helped to divert attention from the promotion of the use of lime in the building industry. Its re-introduction, either singly or in combination with pozzolana would provide an alternative binder to portland cement for low-cost housing construction.

34. The production process for lime consists basically of two stages. Limestone (or dolomite or sea-shells) is first burnt in a kiln at temperatures ranging from about 900 °C, depending on the type of raw material, to produce quicklime. During the second stage, known as slaking or hydration, quicklime reacts with water causing the lumps of quicklime to break down to a fine powder (hydrated lime), which is ready for use as a construction material.

35. Rectangular batch kilns (or open hearths) have traditionally been used in small scale lime production in Africa. These have proved inefficient and wasteful of fuel. Cylindrical vertical shaft kilns (for batch or semi-continuous operation), some originally developed in countries outside Africa, for example India, have been field tested in Tanzania, Togo, Madagascar, Nigeria and Ghana, among other countries. The main fuel used has been firewood although in Tanzania, Malawi and Nigeria the use of coal is possible. Lime hydration methods vary from simple platform slaking to the use of mechanized hydration plants. The latter are however more suited to medium and large scale production although efforts are now being made, for example, in India to develop small mechanical hydrators. The capital cost of a 3-tonne per day lime plant is estimated at US$ 20,000.00.

36. In the promotion of small scale lime production, a major area requiring attention is the development of efficient kilns and burning methods. Simple temperature measuring devices would promote better control of the burning process. Training in quality control covering the different stages of production is also required.

Lime-pozzolana

37. Pozzolanas are not cementitious in themselves but contain constituents which at ordinary temperatures will combine with lime and water to form compounds with cementitious properties. Pozzolanas are grouped into two main classes: natural and artificial. The main source of natural pozzolana in Africa is volcanic ash. The process of producing an intermediate cement from lime and volcanic ash is basically simple. It involves calcination of limestone to obtain lime and intergrinding it with volcanic ash, in a ratio of about 1:2, to the required fineness. In a plant set up in Rwanda, the pozzolana (ash) was interground with lime and portland cement in proportions 25:12.5:62.5 of OPC/lime/pozzolana, and commercialized as a masonry cement. The suitability (reactivity) of the ash should be tested before it is used. The main capital items required are the lime kiln and grinding equipment.

38. Among the sources of artificial pozzolanas in Africa are flyash, calcined clay, calcined bauxite or bauxite waste, and the ashes obtained from the controlled burning of rice husk, coffee husk, groundnut husk and bagasse. The potential for the production of a lime-pozzolana cement based on rice husk ash is great particularly in areas of high rice production. The production technology is simple and has been fairly well developed and tested in Asia (India, Pakistan, Nepal, etc.). In Africa, technology development is at the research stage.

48. The following hints would be helpful in organizing the establishment and operation of the pilot production/demonstration unit.

(i) The pilot production unit should serve to rectify operational difficulties and 'perfect' the technological process before embarking on a programme of technology transfer. Equipment and tools should be tested under field operating conditions and improved as necessary,

(ii) Decentralization of pilot production centres in strategic locations across the country, for example in the areas where raw materials are abundant, would promote the dissemination of the technology. Accessibility to the potential users of the technology should be the guiding principle,

(iii) Viability of the technology should be demonstrable. There should therefore be provision for operating the plant for sufficiently long periods of time in order to assemble data that would be valuable for costing production and evaluating viability either for commercial operations or for community-based projects,

(iv) While conditions at pilot plant sites tend to be "ideal", efforts should be made to approach pratical commercial operating conditions to emphasize that a workable commercial unit can be set up on the basis of the technology being demonstrated. This should be reflected, for example, in the choice of the site, in relation to the supply sources of major raw materials inputs.

(v) Production and utilization manuals should be prepared giving, respectively: details of the production process from the selection of raw materials to the production of the final output giving due attention to quality control procedures, and guidelines on the potential uses and proper applications of the building material or component in the building fabric. These manuals would be useful for training programmes that would be organized for interested entrepreneurs, technicians and community workers;

(vi) Technical personnel at the pilot plant should be trained to be conversant with the details of the technology in order to be able to answer questions posed by enquirers;

(vii) The technical capacities and expertise of the concerned research and development institutions should be properly developed and strengthened to ensure availability of the necessary back-stopping services for the pilot production units to be established. Particularly in respect of the development of technologies for new building materials, adequate resources should be made available to the institutions so that the necessary production parameters and the performance data on the materials can be clearly established. Failures of a couple of plants in the initial stages of the promotion of a new technology can lead to its total rejection, because of failure to undertake thorough research and development work.

IV. POPULARIZATION OF PRODUCTION SYSTEMS FOR LOW-COST BUILDING MATERIALS

49. The development of pilot production units to demonstrate the technical appropriateness of the technologies for selected building materials suitable for utilization in low-cost housing is a necessary, but not sufficient, condition for the acceptance and widespread adoption of the technologies. There should be deliberate concerted action to popularize the production technology and the building materials, first to attract the attention of entrepreneurs to set up production ventures, and then to encourage greater utilization of the materials in housing and other building programmes. Examples abound in African countries of pilot plants which were never replicated because of the absence of aggressive and well-coordinated popularization programmes. Three aspects of popularization programmes can be identified:

(i) Transfer of production technology,

(ii) Demonstration of the use of the building materials,

(iii) Publicity campaigns

Transfer of production technology

50. The main objective of technology transfer in the context of the promotion of low-cost building materials production should be to ensure wider knowledge of and adoption of a specific technology resulting in increased supply of specific building materials. This requires not only the formulation of clearly-defined strategies, but also the provision of adequate resources to ensure sustained actions at the implementation stage. This is all the more important because the materials to be promoted are, in most cases, poorly known in the house building sector. Technology transfer can be effected in three inter-related ways through:

a) documentation
b) training
c) supply of technology package

Documentation

51. Documents containing concise information on building materials technologies serve two primary functions. Firstly, they provide material that can be used directly by experienced technical personnel, for example, information on techniques of soil stabilization. Secondly they provide a link to sources where assistance can be obtained in utilising the technologies. Manuals on the production and utilization of building materials are useful not only as training tools, but also in allaying the fears of potential users about the consequences of adopting the technologies. The technical content of documents

should be adjusted to meet the information needs of different categories of users. In order to reach a wider audience, it would be useful to disseminate publications on local building materials and appropriate building techniques in the predominant local languages. Facilitation of access to publications should be ensured.

Training

52. Training affords the opportunity to directly impart skills and know-how which could then be applied in propagating a technology. Different groups of people may require training - small scale entrepreneurs, village co-operatives, housing co-operatives, small scale development agencies, non-governmental organizations or individual technicians and artisans, the training programmes should meet their specific needs.

53. The organization of training courses in conjunction with pilot plant production activities (demonstration -cum- training centre) offers opportunities for trainees to have on-the-job experience of the various stages in the production process. This mode of training has been used with positive results in some African countries. A variant of this concept is the establishment of building materials production centres within the framework of low-cost housing projects. For example, the Capital Development Authority in Dodoma, Tanzania established in 1980 a building materials centre to develop the use of alternative local building materials using local resources and simple technology. The centre offers advice and training to housing cooperatives, institutions as well as individuals interested in the manufacture of soil blocks and fibre (sisal) concrete roofing products. On acquiring the basic training, interested parties can either hire the equipment from the centre for their individual production or purchase finished products from the centre.

54. A network of training centres covering the whole country would help in accelerating the technology transfer process. In Malawi, the Rural Housing Project has achieved great success in popularizing the production and use of fibre concrete roofing sheets and tiles through a network of Regional Housing Centres and District Housing Centres where sheet and tile makers are trained. As at November, 1987 about 50% of the trainees had been assisted to set up small-scale production units as contractors at the regional and district housing centres.

55. Trained entrepreneurs should be assisted, both technically and financially to set up their own business (see chapter V). This follow-up action should be accorded priority to ensure satisfactory technology transfer. Training can also be arranged as a component of technology packages offered to entrepreneurs.

Supply of technology packages

56. Most small-scale entrepreneurs who are the target group as producers of building materials for low-cost housing possess little technical skills and therefore would benefit from technology packages which can be made available for the setting up of their businesses. Such packages would provide for the supply

and installation of needed equipment, the training of workers and back-up maintenance services. It is expected however that the type of technologies being considered are such that personnel can be trained quickly to undertake the required maintenance and repairs.

57. In Africa research and development institutions have been in the forefront of efforts to develop innovative production technologies. They have generally placed little emphasis on the development of complete business packages that can be offered directly to entrepreneurs or other users. The various elements of such packages are however present in a number of countries within different institutions. Small scale entreprises development organizations or the institutions responsible for the promotion of low-cost materials production should therefore assist the research institutions or other lead agencies to put together marketable packages that can be supplied on request.

58. The content of technology packages would vary depending on the materials in question. In some cases involving improvement of existing technologies there may only be need to supply equipment, like block or brick presses. In these cases it may be necessary only to provide training in the operation of the equipment.

59. Schemes for the transfer of technological know-how can be hampered by the unavailability of the required equipment and tools. It has been emphasized that technologies for promoting low-cost materials manufacture should be based primarily on local resource inputs. Thus, for example, adequate local capacities for the fabrication of equipment and tools should be developed. In situations where critical inputs, like sheet metal, have to be imported, adequate provisions should be made to ensure that demands are satisfied promptly.

Demonstration of the use of building materials

60. The local building materials promoted for low cost housing are often perceived as non-durable and inferior to the more popular conventional materials. Some of these social prejudices are engendered by the use of inappropriate designs and building techniques which fail to exploit the inherent qualities of the materials. There are therefore overriding merits in using demonstration buildings as a means of overcoming public prejudices and promoting increased acceptance of improved lower cost building materials. Increased demands would guarantee a market for the products of new building materials enterprises.

61. In planning and implementing programmes to demonstrate the use of building materials, the following areas of concern should be kept in view:

(i) The programme should involve more than the mere construction of a few housing units or roofs in isolated locations. It should be a sustained effort that could even be incorporated into existing or planned low cost housing projects. Consultations should therefore be held with concerned government and non-government development agencies to elicit their interest in the materials and building techniques being popularized.

(ii) The advice of competent building professionals should be sought in evolving building designs that project the inherent technical and aesthetic qualities of the building materials and components and enhance long-term durability of the finished building. For example, the life of earth buildings can be prolonged by protecting them against moisture attack. In wet humid areas this could be achieved by the use of deep overhangs over buildings, short walls treated with waterproof materials externally, raising the foundation wall sufficiently so that rain splashes will not reach the earth blocks and cause erosion, etc.

(iii) In connection with (ii) above, typical design drawings should be developed and made available to the public at a nominal fee.

(iv) The construction of demonstration buildings should incorporate a scheme to train technicians and artisans in appropriate building techniques for specific materials. Some instructions in materials usage could also be given at building materials production centres. Suitable manuals should be prepared for this purpose. A special scheme should be devised to provide training to artisans operating in the informal building sector.

(v) Programmes to demonstrate improved building materials and techniques in low-income settlements should provide for the participation of the local community. This has been found to be a key factor in successful building technology transfer schemes.

(vi) Programmes of visits to demonstration building sites should be arranged for government decision-makers, entrepreneurs, representatives of financial institutions, building professional associations and low-cost housing development agencies to give them an appreciation of the improved or new materials and techniques.

Publicity campaigns

62. Publicity campaigns should serve as a means of awakening the consciousness of the population to the benefits of, and the available means for producing and utilizing improved or newly developed locally-produced building materials in low-cost housing construction. They should provide the vital link between the field pilot and demonstration projects and the target beneficiaries.

63. The campaigns should be aimed at helping people to overcome deep-seated prejudices and to be attracted to the new opportunities for constructing relatively lower-cost and durable housing units. Campaign programmes should be tailored to specific target groups and the most effective means should be determined and used. The range of activities could include some of the following:

(i) Preparation of short feature films to be shown on television network and/or by mobile cinema vans. The latter would be more effective particularly for the rural areas and low-income settlements in the urban areas.

(ii) Feature programmes and advertisements on national radio and television networks.

(iii) Preparation of slides for presentation to selected audiences.

(iv) Newspaper articles

(v) Preparation and distribution of brochures and information sheets.

64. In order to achieve lasting results, publicity campaigns need to be planned and organized in a sustained manner over a long period of time. The programmes should therefore be imaginative enough to capture the attention of the public during that period.

65. The publicity campaigns are bound to generate requests for further information and it is therefore important to provide guidance on centres or offices where such assistance can be obtained. Successful campaigns cannot be run without adequate financial resources. Governments should therefore confirm their commitment to the increased production and use of local building materials by ensuring adequate financial support to the concerned implementation agencies.

V. DEVELOPMENT OF SMALL SCALE ENTERPRISES FOR THE PRODUCTION OF LOW-COST BUILDING MATERIALS

66. It has already been demonstrated that under the prevailing social and economic conditions in African countries, characterised by surplus labour and low capital, small scale enterprises using low-capital intensive technologies have a great role to play in increasing the supply of reasonably priced local building materials needed for constructing low-income houses. The capacity of small scale enterprises in the building materials sector in Africa is at present poorly developed and deliberate action is required to realise their full potential. Key areas in which measures should be formulated and implemented include the following:

a) Consultancy and advisory services
b) Facilitation of access to credit and financial incentives
c) Training in production and management techniques

Consultancy and advisory services

67. One of the reasons for the low level of development of small-scale enterprises for the production of local building materials is that entrepreneurs are unaware of the opportunities that exist in the sector. Even those who get attracted to some materials ventures find themselves in a maze as they consider the details of how to proceed to realise their goals. Questions of "what," "where" and "how" have to be answered by the potential entrepreneur with regard to the assistance he would require to get himself established in a small-scale enterprise.

68. In devising programmes to promote the development of small-scale production of building materials, therefore, the following measures should be taken.

(i) Create an awareness and interest in potential entrepreneurs about different opportunities for viable business enterprises in the small-scale building materials sector. Use of radio, television and newspaper advertisements and the organization of short seminars are potential channels for reaching out to such entrepreneurs.

(ii) Direct interested entrepreneurs to a centre/office where follow-up enquiries can be dealt with. Small-scale industries development organizations, development banks with departments for small-scale industries promotion, or research and development institutions perform this function in some countries. It is important that the focal institution responsible for dealing with the problems of potential entrepreneurs has the capacity to handle the areas of assistance listed in (iii) - (vi) below within its set-up or maintains a register of other institutions which can be contacted to provide the required assistance. It is also essential to facilitate access to the services provided by the local institution, and in this regard the creation of sub-national branch offices is vital.

(iii) Provision of technical assistance and guidance with respect to: preparation of techno-economic profiles, pre-feasibility and feasibility studies; sources of production technology and selection of plant size and suitable technologies including machinery, plant, equipment and operation of machines; identification and evaluation of raw material reserves to determine their quantity and suitability for the preferred production process.

(iv) Provision of assistance in securing long-term and short-term capital through the banks and other schemes available to small-scale business entrepreneurs. This may include the preparation, submission and follow-up of loan applications.

(v) Advise entrepreneurs on proper methods of business management, including marketing, financial accounting, cost accounting, factory legislation, personnel relations, etc.. Organization of periodic courses tailored to the needs of specific small-scale enterprises, in this case building materials producers, has been found to be an effective way of imparting basic management skills to new entrepreneurs.

(vi) Arrange or assist in arranging training for employees of small-scale industries in basic production and quality control techniques. The entrepreneur should also have an appreciation of the technical aspects of production and would therefore benefit from participation in such training programmes.

69. Consultancy and advisory services should be provided at minimal cost in order not to dampen the enthusiasm of prospective entrepreneurs. While certain services, like advice on viable production possibilities and, types and sources of appropriate technologies, can be provided at virtually no cost, to the entrepreneur, the tendency of recipients to place little premium on free services should serve as a guide. Some small industries development organizations in Africa charge commissions or investigation fees (a small percentage, 1 to 2%, of the loan approved) in respect of specified services, such as one time or continuous provision of technical assistance by the organization.

Facilitation of access to credit and financial incentives

70. The traditional sources of funds for building materials projects are the development finance institutions like industrial development banks, national investment banks and specialized housing finance banks. These banks however, in general do not give concessionary terms for loans for small-scale building materials ventures. A major source of funding for small-scale enterprises is the small-scale industries development organizations which are now found in many African countries. Unfortunately, as at now, the building materials sector does not feature prominently in the projects assisted by many of these organizations.

71. Lack of finance is a major bottleneck to the development of small-scale building materials enterprises, and the current situation in African countries with regard to accessibility to credit facilities, requires a major effort on the part of the agency charged with responsibility for the development of this level of materials production. Innovative and workable approaches should be devised. The following guidelines should be considered:

(i) Undertake periodic reviews of existing facilities for granting credit to small-scale building materials enterprises in order to obtain precise information on deficiencies and extent of problem to be addressed.

(ii) Encourage higher priority to projects in the building materials sector,

(iii) Encourage development finance institutions to create special windows for small-scale industries, including building materials industries, with provisions for concessionary loan terms. Housing finance institutions, where they exist, should be sensitized to give special consideration to loan applications for small-scale building materials manufacture,

(iv) Assist entrepreneurs to satisfy requirements for loan applications, including preparation of feasibility reports;

(v) Give technical assistance to small-scale enterprises in financial management to enhance access to additional banking funds for future operations. In some countries, small industries development organizations grant loans which are considered sufficient to get enterprises started at an economic level of production. At a later stage when they want to expand their businesses, they are expected to go to commercial banks for further financial assistance;

(vi) Seek opportunities to mobilize external funding for developing building materials enterprises, for example within the framework of externally-funded low cost housing schemes;

(vii) Undertake periodic reviews of the financial needs of small-scale building materials enterprises and request government to place special funds or grants at the disposal of funding institutions for disbursement;

(viii) In addition, indirect measures like providing land (for example, raw material deposits) at concessionary rates and supplementary basic infrastructure including access roads to production sites should be used to encourage small-scale enterprises. Other such measures include providing guarantees for import of basic machinery and equipment whose local manufacture has not yet been developed, and ensuring the availability and support of technical backstopping services.

Training in production and management techniques

72. Entrepreneurs in the small-scale production sector require training in two broad areas: production techniques and personnel and financial management.

Production techniques

73. The entrepreneur should acquaint himself with the elements of basic production techniques to enable him exercise proper control over the labour force in order to ensure achievement of production targets. In this regard, the entrepreneur should receive instruction on the establishment and maintenance of proper quality control procedures at all stages of the production process. The consequences of failure to adopt stipulated procedures should be clearly spelt out.

Personnel and financial management

74. The small-scale entrepreneur should learn to operate along sound business principles in order to increase chances of success and operational profitability. The training should aim at imparting basic skills in accounting, organization and management of production labour, inventory control and marketing. Records of business operations should be properly kept to facilitate preparation of financial statements that can be used to support future requests for funding from the banks. The entrepreneur should learn to avoid over-personalization of business operations and should employ competent personnel to help realize the production objectives.

75. The following considerations should guide the preparation and organization of training for entrepreneurs:

(i) Training should be viewed as a continuing process until such time that the entrepreneur becomes fully conversant with all the basic skills required and is able to put his business on a sound financial footing, assuming that problems regarding production inputs, particularly capital and raw materials, are brought under control. Training needs of individual entrepreneurs should therefore be evaluated periodically and planned for;

(ii) Training courses should focus on imparting practical skills which would be of immediate utility to the entrepreneur. The use of workshops as a training medium should therefore be emphasized. Demonstration -cum- training centres where entrepreneurs, as well as their technicians, are given opportunities to acquire on-the-job skill in materials production methods have been used with a high degree of success in some countries. In many countries, research and development institutes are playing the lead role in the development of appropriate production technologies for local building materials. Their facilities and expertise can be drawn upon in the organization of training for entrepreneurs;

(iii) Manuals on the production and utilization of the various building materials whose development is being promoted in the country should be prepared for use by entrepreneurs. The production manual should stress raw materials selection and preparation, the correct production processes and quality control procedures, as well as simple field tests for raw materials and finished products;

(iv) The organization responsible for the development of small-scale building materials enterprises should develop a strong training unit manned by qualified personnel. The unit should identify and involve, in its activities, existing national institutions with facilities for providing training in any of the areas identified as necessary for building up the competence of entrepreneurs.

VI. INSTITUTIONAL SUPPORT

76. A number of measures whose implementation would contribute significantly to the further development of the production of low priced building materials have been outlined in the foregoing chapters. They cover a multiplicity of functions which in most African countries are carried out by different ministries, agencies and institutions with little interaction and coordination among their respective programmes. This lack of focussed attention in dealing with the problems of the building materials sector stands out as one of the major causes of the slow pace of progress in achieving a widespread production and use of local building materials with potential for reducing the cost of housing construction for the poor. Inter-ministerial coordinating committees have been set up in some countries but their effectiveness has often been limited.

77. It would be impracticable, in the short term, for countries to create an administrative structure that will concentrate full responsibility for the development of local building materials in one ministry or agency. What could possibly be done would be to strengthen one of the most directly concerned existing organizations and charge it with the task of coordinating the implementation of government decisions and priorities for achieving progressive improvement in the supply of building materials for low-cost housing. This responsibility should cover both the public and private sector, and also the formal and informal sectors. The potential for increased materials production by small scale enterprises, as well as through self-help and community group efforts should all be developed.

78. In organizing the coordinating functions for ensuring adequate institutional support to entrepreneurs and other potential producers, the following functions should be kept in view, particularly with respect to the areas outlined below:

Information

(i) Determine gaps in information supply and organize in collaboration with the concerned agencies, the preparation of the necessary documentation.

(ii) Ensure easy access to relevant information including: location and suitability of raw materials, catalogue of viable projects for commercial production of building materials, appropriate technologies and their sources, institutions from whom various types of assistance can be obtained, etc. In this connection the setting up of a data base and building materials information centres would be appropriate;

(iii) Ensure co-ordinated continuing popularization programmes with the purpose of gaining widespread public acceptance of local building materials susceptible to adoption in low-cost housing construction.

(iv) Establish co-operation links with institutions in other countries in Africa and the developing world with a view to sharing experiences in the development and application of appropriate building materials production technologies.

Technology

(i) Undertake follow-up of successful applications of specific technologies in commercial or self-help projects for the purpose of their popularization;

(ii) Organize the preparation of profiles of appropriate technologies having potential application in different production situations. Techno-economic profiles which provide general indication of viability of the production of specific building materials would be helpful to entrepreneurs;

(iii) Ensure the strengthening of the capacities of research and development institutions to provide technical back-stopping, including training, to production ventures, particularly in the small scale formal and informal sectors;

(iv) Undertake continuous assessment of low-cost materials technology with a view to their improvement. Also encourage the development of new local technologies for the use of hitherto untapped raw materials resources, or adapt suitable foreign technologies for local application. The ultimate objective should be to localize appropriate technology development, maintenance and application.

Small-scale enterprises

(i) Strengthen existing institutions with responsibility for promoting the development of small scale enterprises to focus more attention on building materials projects. Where such institutional arrangements do not exist, the coordinating agency may assume responsibility for organizing the necessary assistance and support for such enterprises;

(ii) Areas of assistance to small-scale enterprises have been discussed in chapter V. These should constitute the focus of attention of the coordinating agency. Special attention should be devoted to devising innovative schemes to mobilize funds for the enterprises.

Self-help and community participation

(i) Maintain close links with both public and private organizations with interest in rural and low-income housing development to ensure adoption of appropriate materials and techniques in their projects. A training component should be built into such projects to promote technology transfer;

(ii) Develop and encourage co-operative efforts in materials production for sale or direct use on housing projects;

(iii) Enhance accessibility of private individuals and community groups to centres where assistance can be received concerning the production of building materials and their use in housing construction.

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Table 1: Comparative assessment of some fibre concrete roofing technologies.

Equipment	Cost US$	Other Requirements	Output Per Day		Materials Used Per Day (kg)			Labour Requirement	Product	Comments
			No.	M^2 Covered	Cement	Sand	Fibre			
Parry electrical vibrator + 200 moulds and some accessories(U.K.)	3800	Building, curing tanks, battery or electricity supply and battery charger, hand tools*, plastic sheet	200 tiles	15.5	90	270	2.8	3 men	Tiles (mm) (500x250x6)	
Parry hand powered vibrator +150 moulds and some accessories	3100	Building, curing tanks, hand tools*, plastic sheet	150 tiles	11.5	68	203	2.1	4 men	Tiles (500x250x6)	
Eco systems hand powered vibrator + one 'grandmother mould'(Malawi)	150	Building, curing tanks, hand tools*, batching boxes, plastic sheet, concrete moulds made from "grandmother mould"	120 tiles	15.0	90	180		4 men	Tiles (600x285x6)	The originator of this system did not use fibre - NOTE cost of equipment does not include moulds
Typical hand vibrated sheet making system incl. 15 asbestos moulds	800	Building, curing tanks, hand tools*, plastic sheet	15 sheets	10	152	152	4.5	4 men	Sheets (100x850x10)	
NFC Semi mechanised factory(Sweden)	Exact figures unknown but NFC estimate total investment in 1985 at between US$400-450,000 depending upon local conditions		400 sheets	292	1890	5670	unknown	unknown	Sheets (1200x733x8)	Imported additive trade name 'Acacil' is also used. Proportion unknown

*Hand tools = wheel barrow, watering can, bucket, shovel, broom, sieve, hand pan, brush, machete, plastering trowel

Source: Intermediate Technology Development Group (U.K.), 1987.

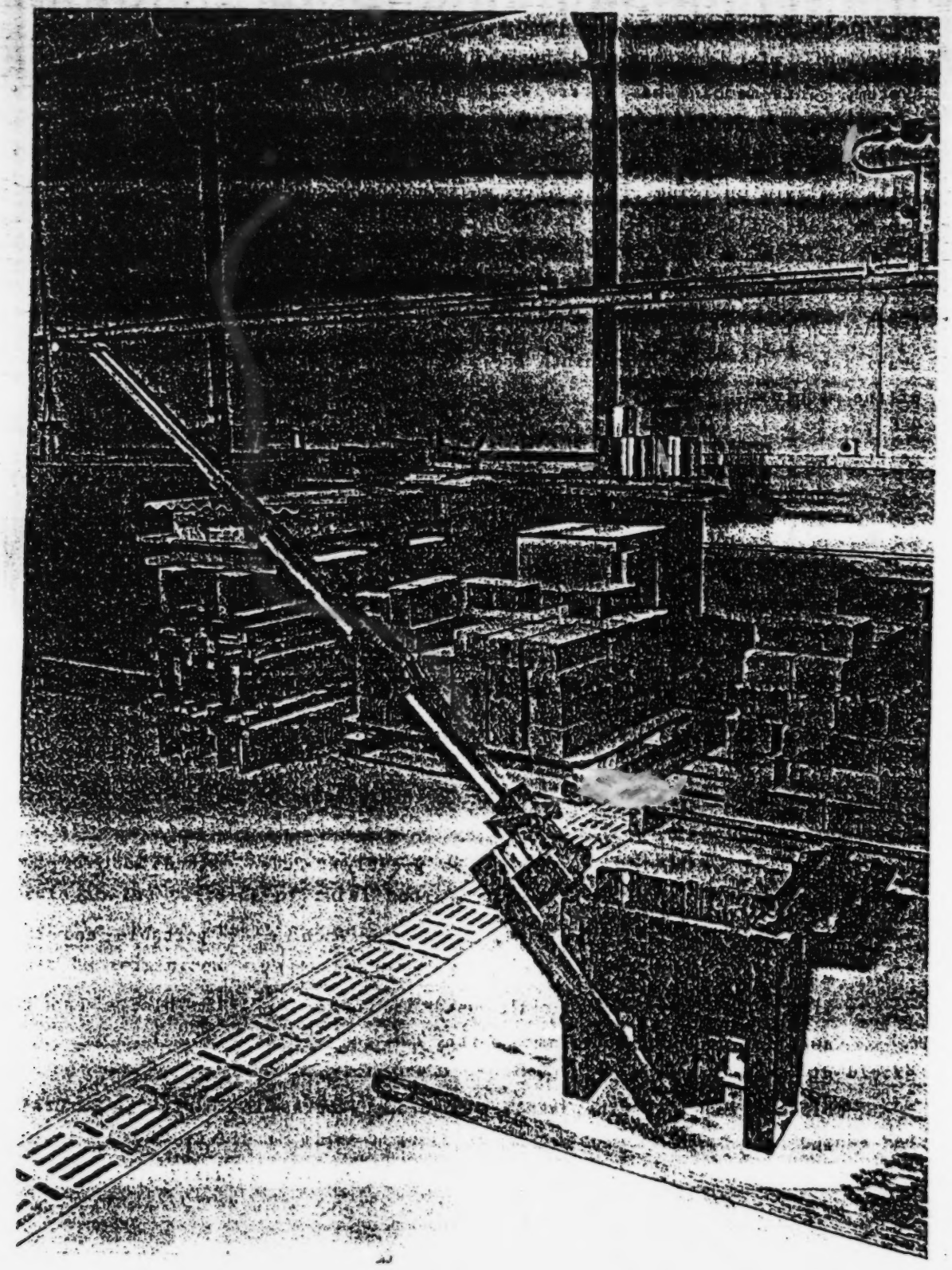


Figure 1

The CINVA-Ram block making machine

Source: ILO - Small-scale manufacture of stabilised soil blocks. 1987.

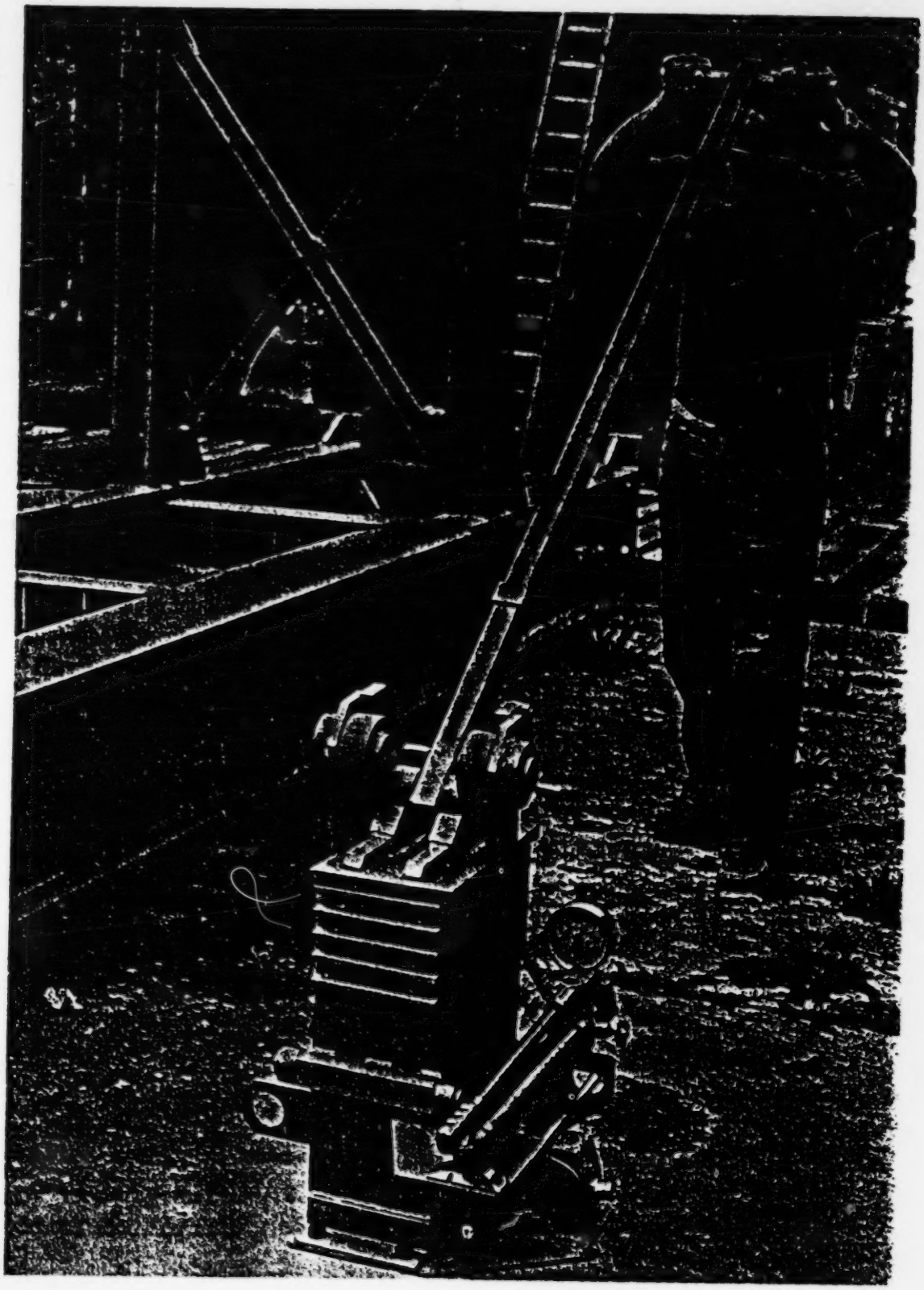
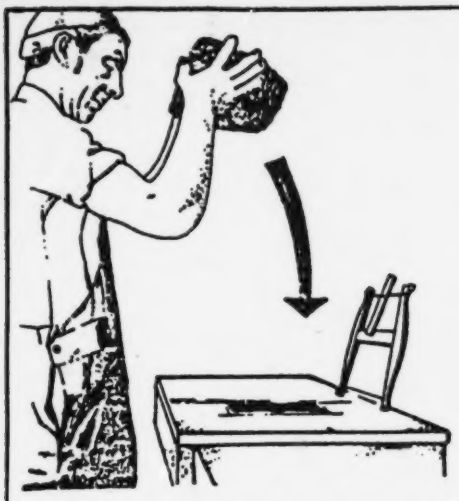


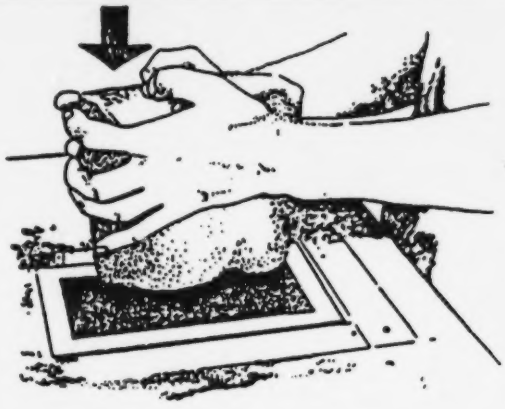
Figure 2

The Brepak machine

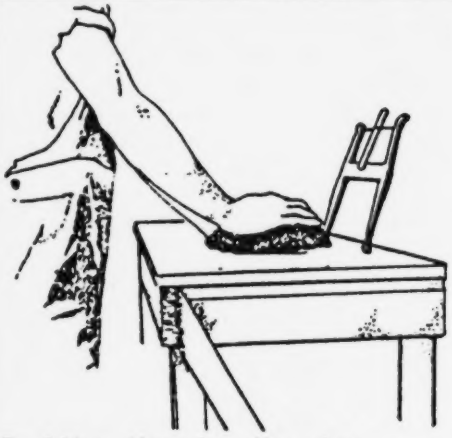
Source: ILO - Small-scale manufacture of stabilised soil blocks, 1987.



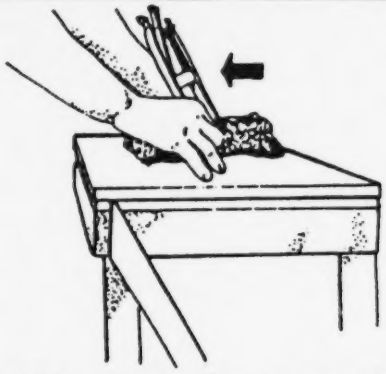
1. The wedge shaped clot of clay thrown forcibly into mould cavity.



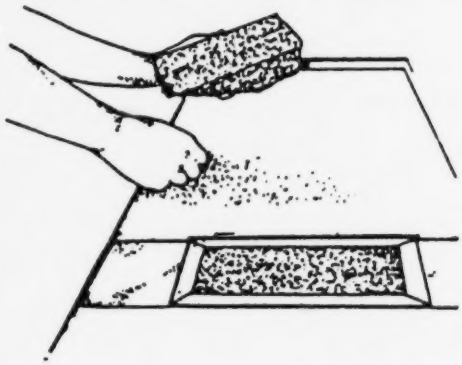
2. At point of entry the bottom of the wedge of clay should come inside the rim of the mould on all sides to avoid 'cutting'.



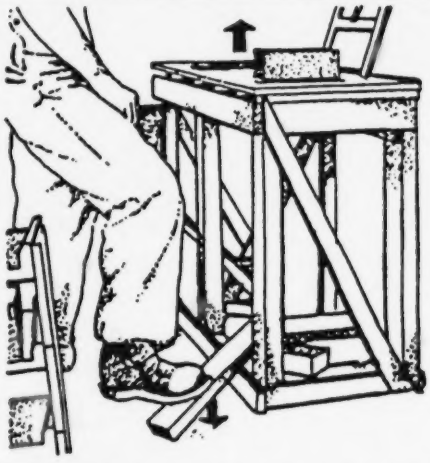
3. After throwing the clot, a small mound of excess clay should be left on top.



4. This excess clay is cut off with the bow cutter.



5. The off-cut is removed and set aside.



6. The pedal is pressed down to eject the brick.

Figure 5

Operation of the table mould

Source: ILO - Small-scale brickmaking. Technical memorandum No.6. 1984

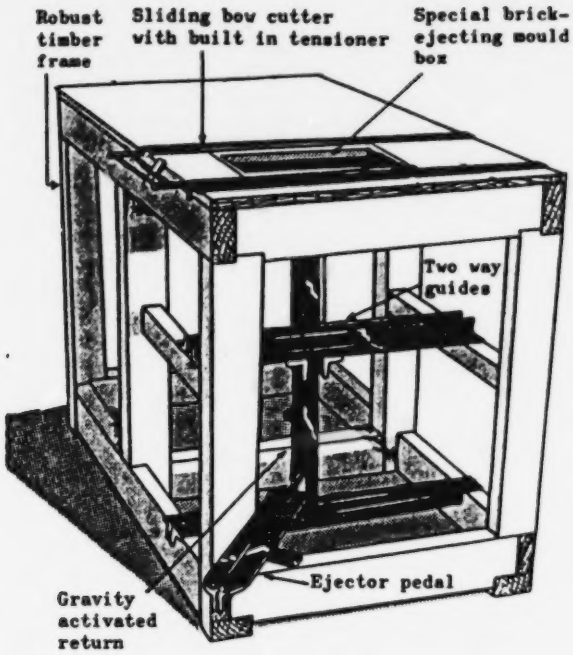


Figure 3

The table mould

Figure 4

Table mould; pedal being depressed to eject brick. Each brick is handled with pallets and stacked on racks (United Kingdom)

Source: ILO - Small-scale brickmaking. Technical memorandum No.6. 1984

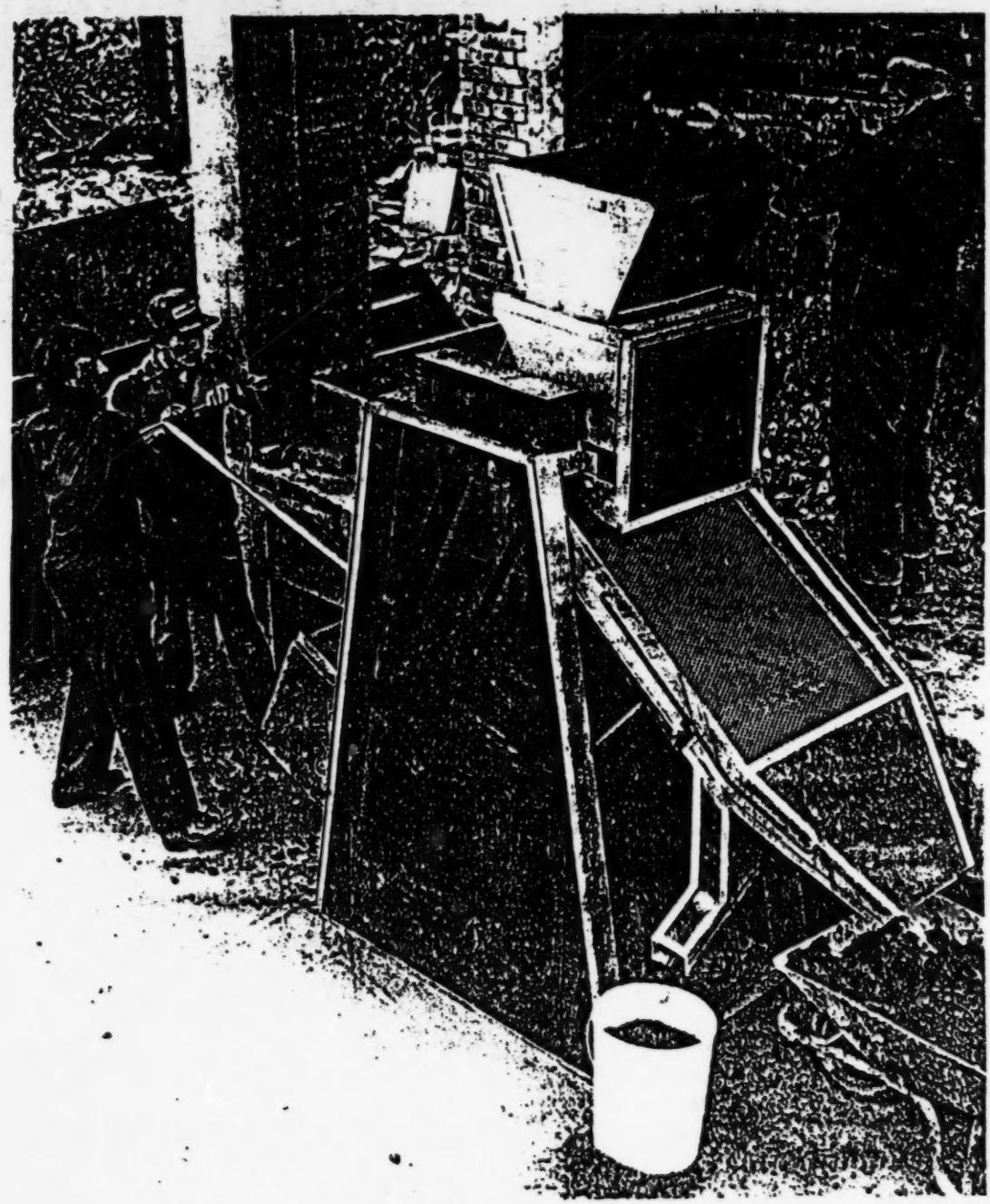


Figure 6

Manually-powered pendulum crusher

Source: ILO - Small-scale brickmaking. Technical Memorandum No. 6 1984